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Public support for river restoration funding in relation to local river ecomorphology, population density, and mean income

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1. Introduction

[2] There is evidence that degradation of running waters is at an all-time high [*Gleick*, 2003]. In the United States, more than one third of the rivers are listed as impaired or polluted [*U.S. Environmental Protection Agency*, 2000]. Extinction rates of freshwater fauna are five times that for terrestrial biota [*Sand-Jensen*, 2001]. However, river restoration is gaining importance on public policy agendas in many parts of the world. For instance, *Bernhardt et al.* [2005] find that the number of river restoration projects in the United States increased exponentially during the last decade, and they estimate that at least $14 billion has been spent on restoration of streams and rivers since 1990. In Europe, the costs of restoring the Emscher river system alone (starting 1990 in a German industrial area) is estimated at € 4.4 billion (Emschergenossenschaft, http://www.emscherumbau.de). A wide range of values, nature discourses, historical experiences, and technical expertise have shaped current restoration efforts [*Eden et al.*, 2000; *Clark*, 2004; *Rohde et al.*, 2005; *Gowan et al.*, 2006].

[3] With large and increasing expenditures for river restoration, an important question concerns also how these restoration projects should be financed. Appropriate financing schemes may promote the public acceptance and perceived success of river restoration. Which level of government should be responsible? Who should contribute how much to the financing of river restoration? From a public finance perspective, answering these questions requires an understanding of how the social benefits of river restoration are distributed, both geographically and across income groups [*Bergstrom*, 1979; *Stiglitz*, 2000]. Estimating benefits of river restoration has previously been approached using survey techniques such as contingent travel cost methods [*Loomis*, 2002], contingent valuation [*Hanley et al.*, 2003], and multiattribute choice experiments [*Collins et al.*, 2005], although these approaches remain controversial [e.g., *Schläpfer and Hanley*, 2006].

[4] Another approach to studying the distribution of the benefits of public services is the analysis of voting behavior in ballot decisions [*Deacon and Shapiro*, 1975]. In the present study, we take advantage of a unique opportunity afforded by a popular decision on a large river restoration program in Switzerland. In 1997, about 140,000 voters in 388 districts of the canton ("state") of Bern voted on a proposition to dedicate an annual amount of about 3 million Swiss Francs (SFR) of the cantonal budget to a fund for financing a canton-wide river restoration program. The district-level voting returns together with district-level socioeconomic data and detailed georeferenced information on the ecological status of the rivers in the study region allow us to study the public support for regional (canton-wide) river restoration in relation to a number of important municipality-level variables.

[5] The main goal of the present study is to relate voter support for regional river restoration to the current ecomorphological status of the local rivers, and to local mean income. From a public finance perspective, information about these relationships is clearly important for policy design. In countries with multilevel government such information is also important for assigning political responsibilities and distributing costs in such ways that democratic decision-making processes and stakeholder involvement result in an efficient allocation of public funds. In addition, the analysis examines the role of further demographic and sociological variables as potential determinants of voter support for river restoration.

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[6] Using a multiple regression framework, we find that public support for river restoration increases with increasing population density, and we also find some evidence that support increases with decreasing "naturalness" of local rivers. Furthermore, the results suggest a high income elasticity of public support (and hence willingness to pay) for river restoration. The marginal effect estimates can be used to predict public support for river restoration in other, economically and culturally comparable regions of Switzerland, Europe, and elsewhere, and they provide a rare empirical foundation for the design of acceptable financing schemes.

2. Conceptual Framework

[7] The present analysis assumes that the nonmarket benefits derived from rivers are public goods. Voting on referenda has long been used to characterize the demand for public goods. The present study starts from the basic conceptual framework of *Deacon and Shapiro* [1975]. An individual *i* votes in favor of the proposed policy if his or her expected utility if the referendum passes is increased. Several studies have related voter support for public policies to income and various other characteristics of voter populations [e.g., *Deacon and Shapiro*, 1975; *Kahn and Matsusaka*, 1997; *Thalmann*, 2004]. These studies have confirmed that voting can be explained at least partly by selfish motives, that the support for environmental policies typically increases with income, and that approval rates are consistently associated with variables related to the costs a proposed policy might impose on the voters such as the extent of employment in particular industries and occupations. More recently, however, a few important issues in the economic interpretation of voting behavior have been raised. In the following, we point to these issues, and we explain how we cope with them in the present study.

[8] First, the costs of proposed policies to the voters may arise in many forms, including reduced employment opportunities or increased prices which are difficult to evaluate [*Schläpfer et al.*, 2005]. Hence many previous economic analyses of environmental policy referenda such as those by *Deacon and Shapiro* [1975] or *Fischel* [1979] have provided little information on willingness to pay for specific public goods. However, there is one particular class of referenda in which the costs of the proposed policy are reasonably well defined. In public financing referenda, citizens vote on whether they should tax themselves in order to finance a particular public service. The individual tax burden is clearly defined by the tax schedule according to which the public revenues for the proposed service are raised. If this expenditure is relatively small, then its effect on the prices of other goods and services or on employment opportunities may be negligible [*Schläpfer et al.*, 2005]. One of the first studies analyzing public support for specific environmental financing propositions is by *Kline and Wichelns* [1994], who examine the determinants of public support for purchasing development rights to farmland in the United States; another is by *Schläpfer and Hanley* [2003], who analyze voter support for landscape amenities management in Switzerland. The present study likewise analyzes voting behavior in a specific public financing proposition.

[9] Second, it has been noted in the public choice literature that the instrumental utility of casting a well-considered vote is minimal in mass elections [e.g., *Mueller*, 2003]. However, studies of voting behavior have consistently shown that voters invest considerable effort in gathering information or information short cuts such as political endorsements [*Lupia*, 1994]. Moreover, norms appear to promote the private benefits of being informed and going to the polls [*Frey*, 1994] and may induce voters to cast votes as if their vote was decisive [*Shapiro and Deacon*, 1996; *Mueller*, 2003] and *as if* they were well informed about the personal consequences of the proposed policies [*Lupia*, 1994; *Lupia and Matsusaka*, 2004]. Hence, as in previous studies, our approach assumes that rational voters cast ballots in their perceived self-interest and that the voting decision is reached by comparing the highest attainable utility under the outcomes of the policy alternatives [*Deacon and Shapiro*, 1975]. However, in light of the more recent research, voters may be motivated to gather information and to go to the polls by other than instrumental aspects, while their votes nevertheless reflect instrumental values. Furthermore, the voters' utility function may include community-wide benefits [*Shabman and Stephenson*, 1992, 1996].

[10] Third, there is the issue that, typically, only the aggregate voting returns of entire voting districts are available. With such data, it is in general not possible to make inferences regarding how individual socioeconomic characteristics such as age, gender, or income affect voting behavior, unless some very strong assumptions about the distribution of these characteristics are made. However, aggregate voting returns are perfectly suited to analyze how location characteristics such as ambient environmental quality or local population density determine voter support of referendum propositions. These effects of local characteristics are the primary interest in the present analysis.

[11] Here, we analyze voter support for a cantonal referendum proposition to finance river restoration in the canton of Bern, Switzerland. Conceptually, the aggregate voting data and georeferenced ecological data set we use are particularly suitable for studying the spatial relationships between the local ecological status of the rivers and the benefits of river restoration perceived by local populations. We hypothesize that local populations do perceive the ecological status of local rivers, and that this perception drives their responses to the referendum proposition. Specifically, we expect that public support for river restoration increases with increasing density and with decreasing "naturalness" of the local rivers. For the latter there are two reasons: (1) a voter near a low-quality river is likely to have a high marginal utility for improvement and (2) a low-quality river is likely to experience greater improvement than a high-quality river if the referendum passes. We also expect that public support for the cantonal program increases with population density. Finally, we examine how local mean income, geographic regions, and two sociological variables, language and the recent local experience of floods, are related to public support, although we do not have clear expectations regarding the direction of these effect. Since the public revenues are generated through progressive income taxes, the sign of the income effect will depend on whether willingness to pay rises faster (with increasing income) than the expected tax increase if the referendum passes.

[12] We do not try to analyze how further socioeconomic variables such as education may affect voter support. In aggregate data, such variables tend to be strongly correlated with income and thus have little additional explanatory power. While any observed relationship between voter support and income cannot be unambiguously causally related to income, the relationship with income, without controlling for correlated variables such as population density, is nevertheless of particular interest as it sheds light on the relative acceptability of alternative financing arrangements with more "progressive" or "degressive" tax implications.

3. Data and Methods

3.1. River Restoration Issue in Switzerland and Its Cantons

[13] River restoration is a longstanding issue on the political agenda in Switzerland at both federal and cantonal levels. On the basis of the federal Law on the Protection of Water Resources ("Gewässerschutzgesetz") of 1991, passed by popular vote in the same year, the cantons are responsible for passing and enforcing legislation regarding the protection and management of water resources in agreement with the general objectives outlined in the federal law (article 45). The federal law places great emphasis on the restoration of water bodies as natural habitats for plants and animals (article 1). For instance, it specifically demands that constructions for river channel stabilization and flood prevention should maintain near-natural habitats (article 50). Appendix 1 of the by-law of 1998 ("Gewässerschutzverordnung"), formulates ecological goals for surface waters which are to be respected when stabilization or flood prevention measures are undertaken. The cantonal efforts are supported by the federal government with annually about 7 Mio. Swiss Francs (SFR) for river restoration efforts and another SFR 13 Mio. for combined restoration/flood prevention projects (R. Estoppey, Water Division, Federal Office of Environment, personal communication). Current revisions of the cantonal laws are expected to define the division of responsibilities between the cantons and the municipalities more precisely. As a most recent development (in 2006), the Swiss anglers association has collected the necessary number of signatures for a national ballot initiative to speed up river restoration by the cantons.

3.2. River Restoration Proposition in the Canton of Bern

[14] In November 1997 the citizens of the canton of Bern were asked to vote on a proposal to establish a cantonal fund for river restoration. This fund was proposed in the context of a revision of the cantonal law on water resources whose main objective was to adapt an earlier law from 1950 to more modern requirements concerning procedures and responsibilities.

[15] The need for a revision and modernization of the law was not contested by any side in the parliament. Only the use of the cantonal income from water licensing was controversial. A strong minority of 70 (out of 171) members of the parliament voted against the revised law, arguing that an earmarked fund for river restoration should be established. In the following, a popular initiative spearheaded by the environmental NGO *Pro Natura* and the cantonal anglers' association formulated a "Proposition for a river restoration fund in the water resources law". The initiative specifically proposed to amend the new law by a provision that 10% of both nonrecurring and annual cantonal revenues from water licensing, about 3 million SFR per year, must be used for restoration projects. According to constitutional provisions, a public referendum had to be held in which the law passed by the parliament had to be confronted with the amended version of the law as demanded by the initiative. The initiative committee argued that, considering the current state of the rivers, the "almost symbolic" expenditures for river restoration flowing from the ordinary budget were not sufficient for the task. The opponents of the initiative argued that, considering the state of the cantonal finances, the budget authority of the parliament should not be restricted. The parliament confirmed the preference for its own proposition and hence recommended (with 88 against 72 votes) to reject the initiative. The official voter information booklet presented the issue on seven pages of text which also included a simple table describing the difference between the two alternatives and one page listing the arguments of the two sides. These pages were followed by the original text of the new law (11 pages) and the proposed amendment (2 pages).

[16] To correctly interpret the voting decision, it is important to note that the initiative explicitly stated that water fees would not be increased. This fact was also highlighted in the official voter information. The only difference to the parliamentary proposition was that 10% of the revenues from water licensing would flow into river restoration projects. The increase of expenditures for river restoration due to the 10% rule would therefore have to be balanced by a corresponding increase of the revenues generated through direct taxation. Clearly, the costs of increasing expenditures for river restoration would be distributed according to the tax schedule of the cantonal taxes on income and wealth.

[17] The mean taxable income in the canton of Bern in 1997 was SFR 50,400. The cantonal tax obligation for individuals with this income was SFR 4850 per year based on the tax schedule for singles and SFR 4150 based on the tax schedule for couples [*Canton of Bern*, 2000]. The SFR 3 million annual expenditure for river restoration represents about 0.1% of the canton of Bern's annual tax income of about SFR 3 billion [*Finance Office of the Canton of Bern*, 1998]. Hence the annual costs of the proposed expenditure for river restoration in the canton of Bern for the mean tax payer amounted to about SFR 4–5, or about US$ 3–4, per year. The income taxes in the canton of Bern are weakly progressive. The annual cantonal income tax burden of an individual with a taxable income of SFR 100,000 was about SFR 13,000 and his or her share of the 3 million expenditure was about SFR 13. Neglecting in this calculation the (relatively minor) taxes on wealth implies the assumption that the individual shares of the wealth tax are proportional to those of the income tax.

[18] The total percentage of yes votes among valid votes in the canton was 54.1% [*Canton of Bern*, 1997]. The river restoration initiative thus passed in the popular decision. The percentage of yes votes in the individual municipalities is shown in Figure 1. Voter turnout was 21.1%, which is not

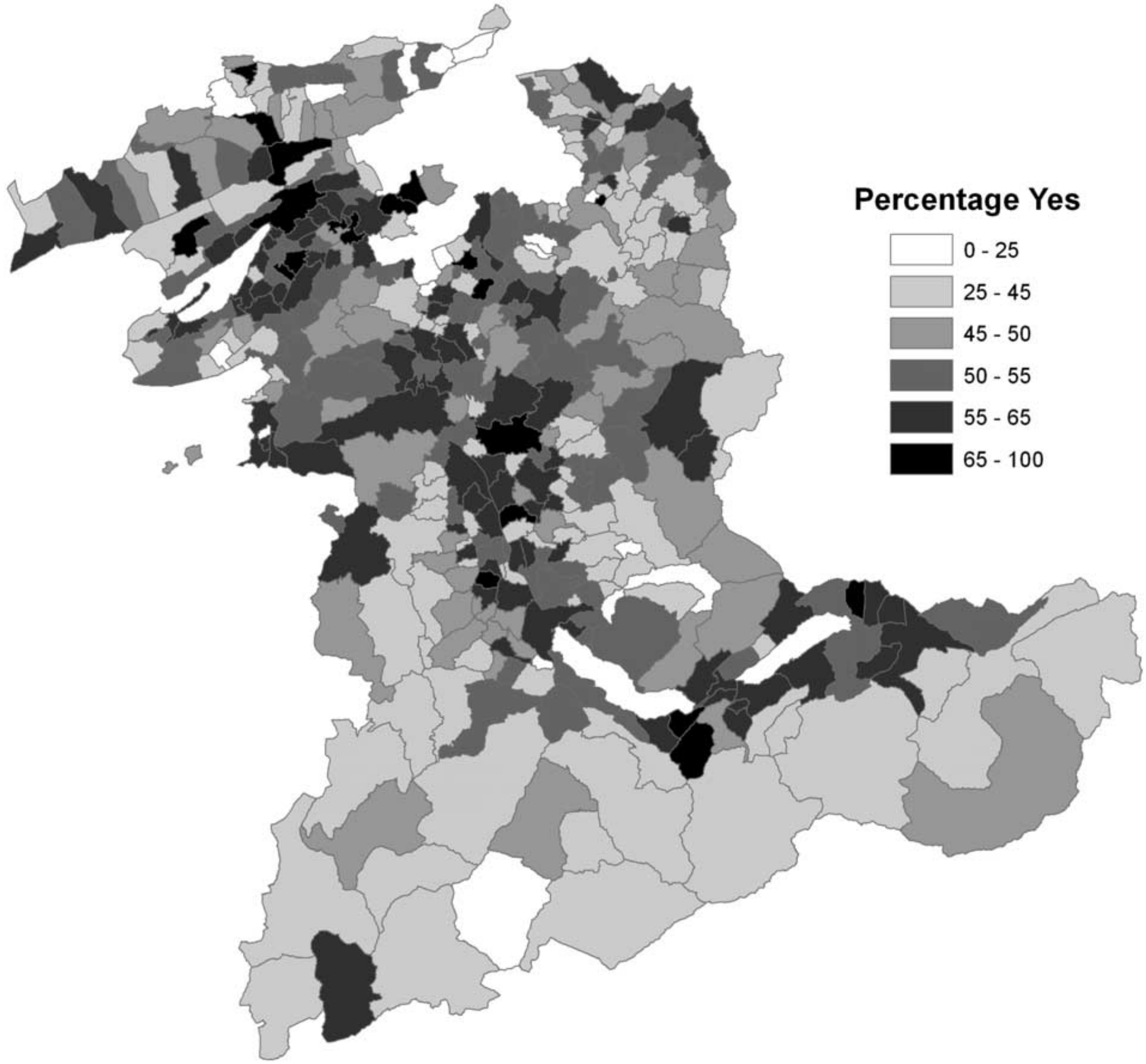

Figure 1. Aggregate voting returns in the municipalities of the Swiss canton of Bern.

unusual for a Swiss cantonal referendum of relatively minor importance (see expected tax increase above). As in any analysis of voting, the results relate to the preferences of the voter sample. They can only be generalized to the whole population under the assumption that the sample is representative.

[19] Following our conceptual framework, we conceive the approval in the individual voting districts (municipalities) for the cantonal river restoration funding as a function of (1) the current ecomorphological status of the local rivers and local river "quantity" or density, (2) mean income in the local population, and (3) additional variables that potentially affected the perception of the issue and the voting decision itself, most notably population density in the municipalities.

3.3. Definition of Variables

[20] Information describing the spatial configuration and ecomorphological status of the rivers in the municipalities of the canton of Bern was available from a detailed georeferenced data set of the Water and Soil Protection Laboratory (WSPL) of the Canton of Bern [*WSPL*, 2003]. These data had been collected in a project initiated in 1997. They contain structural characteristics of the rivers recorded using methods defined by the *Federal Office for the Environment, Forest, and Landscape* (*FOEFL*) [1999]. Field-recorded attributes characterize the ecomorphological conditions of homogeneous river segments (Table 1). For each river segment the data set also provides a Naturalness Index generated through a scoring of the field-recorded attributes (Tables 1 and 2). The data are linked to a digital vector map of the rivers. A comprehensive documentation of the data set is available from *WSPL* [2003] and *FOEFL* [1999].

[21] A variable RIVNAT for the "naturalness" of the rivers in the vicinity of the municipal centers was derived using a geographic information system (GIS). The vector data set of the rivers was linked with a vector map containing municipal boundaries and town centers [*Swisstopo*, 1999a,

Table 1. Attributes of River Ecomorphology and Their Scoring in the Naturalness Index[a]

Attribute	Description	Score
Variability of river width	very variable	0.0
Variability of river width	moderate	2.0
Variability of river width	none	3.0
Bed stabilization	none	0.0
Bed stabilization	<10%	1.0
Bed stabilization	10–30%	2.0
Bed stabilization	>30%, riprap	2.0
Bed stabilization	>30%, all other materials	3.0
Stabilization of embankment[b]		3.0
Stabilization of embankment[b]	<10%, permeable	0.0
Stabilization of embankment[b]	<10%, impermeable	0.0
Stabilization of embankment[b]	10–30%, permeable	0.5
Stabilization of embankment[b]	10–30%, impermeable	1.0
Stabilization of embankment[b]	30–60%, permeable	1.5
Stabilization of embankment[b]	30–60%, impermeable	2.0
Stabilization of embankment[b]	>60%, permeable	2.5
Stabilization of embankment[b]	>60%, impermeable	3.0
Riparian zone/vegetation[b]	sufficient width, natural	0.0
Riparian zone/vegetation[b]	sufficient width, nonnatural	1.5
Riparian zone/vegetation[b]	sufficient width, artificial	3.0
Riparian zone/vegetation[b]	insufficient width, natural	2.0
Riparian zone/vegetation[b]	insufficient width, nonnatural	3.0
Riparian zone/vegetation[b]	insufficient width, artificial	3.0
Riparian zone/vegetation[b]	no riparian zone	3.0

[a]Source: *FOEFL* [1999].
[b]The scores of the two riversides were assessed separately and averaged for the slope and riparian zone attributes.

1999b, 1999c, 1999d]. Using standard tools in ArcGIS 9.0, the weighted mean Naturalness Index of the river segments located within a given radius r from the town centers was computed, yielding the variables $\mathrm{RIVNAT}_{1\mathrm{km}}$, $\mathrm{RIVNAT}_{2\mathrm{km}}$ and $\mathrm{RIVNAT}_{5\mathrm{km}}$ (Figure 2). Weighting of the Naturalness index occurred by river density as defined as follows. The variable $\mathrm{RIVDENS}_r$ for the density of rivers was derived as L_r/A_r, where L_r is the total length of all river segments located within a given radius r from the municipal center i (and located within the canton of Bern), and A_r is the area within this radius that is located within the canton of Bern. This definition accounts for the fact that some of the radii overlap with the cantonal boundaries and information about the ecomorphology of the rivers outside the cantonal boundaries was not available.

[22] Mean income per taxpayer (INCOME) in the voting districts (municipalities) was computed from the total of reported net incomes in the tax period 1997/1998 and the number of taxpayers (“normal cases and special cases with a direct federal tax burden”) which are reported in the federal tax administration’s publication for the tax period 1999/2000 [*Federal Tax Administration* (*FTA*), 2004]. For population density (POPDENS) we used the population data of the 1990 census [*FTA*, 2004] and the land surface from the Canton of Bern *Office for Municipalities and Spatial Planning* (*OMSP*) [2002]. With both INCOME and POPDENS we used the log-transformed data as this specification substantially improved model fit.

[23] A dummy variable DAMAGE for the occurrence of water related damages (by floods and landslides) was coded based on the flood and landslide database of the Federal Research Institute WSL, Birmensdorf [*Hegg et al.*, 2000]. The variable indicates whether a municipality had been a “main affected municipality” of a flood or landslide at least once during the 10 year period prior to the referendum. Finally, a dummy variable LANGUAGE (for Germanic versus Romanic language and cultural background) and the dummy variables JURA, PREALPS and ALPS (for four main geographic regions with Swiss Plateau as the reference) are based on data from the Office of Municipalities and Spatial Planning, Canton of Bern [*OMSP*, 2002]. Descriptive statistics for the independent variables (except the region dummies) are summarized in Table 3.

[24] In eleven cases, the voting districts comprised two (ten cases) or three (one case) municipalities with small populations. As votes cannot be spatially related to rivers in these cases, these municipalities were eliminated from the data set. For the same reason, the (few) fragmented municipalities were eliminated from the data set, yielding a data set with 366 observations.

3.4. Estimation

[25] We used ordinary least squares to estimate the following model of the logit-transformed approval rates in the voting districts [*Kline and Wichelns*, 1994]:

$$
\begin{aligned}
ln(F/(1-F)) = \alpha &+ \beta_1 \mathrm{POPDENS} + \beta_2 \log(\mathrm{INCOME}) \\
&+ \beta_3 \log(\mathrm{LANGUAGE}) + \beta_4 \mathrm{DAMAGE} \\
&+ (3 \text{ region dummies}) + \beta_8 \mathrm{RIVDENS}_r \\
&+ \beta_9 \mathrm{RIVNAT}_r + \beta_{10} \mathrm{RIVDENS}_r \\
&\times \mathrm{RIVNAT}_r + e
\end{aligned}
$$

Indices i = 1,. . ..366 for the municipalities are omitted. In this equation F is the fraction of approving votes cast in municipality i; e is a disturbance term, and β_1 to β_{10} indicate the parameters to be estimated. In cases where no rivers were present within a given radius from the population center – and hence no value could be computed for RIVNAT_r – the observation was omitted from the data set. This yielded the sample sizes n = 354 (r = 1 km), 365 (r = 2 km) and 366 (r = 5 km). To allow logit transformation of the dependent variable also in one small municipality with zero Yes votes, we defined F as the fraction of approving votes in a municipality +0.01. The interaction term (last variable in the model) is added because any effect of river naturalness (RIVNAT_r) may quite reasonably be expected to depend on the density of local rivers ($\mathrm{RIVDENS}_r$).

[26] To control for heteroscedasticity we also computed White’s heteroscedasticity-consistent standard errors and weighted least squares (WLS) regressions. We used

Table 2. “Naturalness” Classification and Coding[a]

Sum of Scores Rounded off to an Integer[b]	Classification	Naturalness Index[b]
0 and 1	natural or near-natural state	5
2 to 5	slightly impaired	4
6 to 9	strongly impaired	3
10 to 12	artificial state	2
-	under ground	1

[a]Source: *WSPL* [2003].
[b]Order of the scale reversed from the original data set for ease of interpretation.

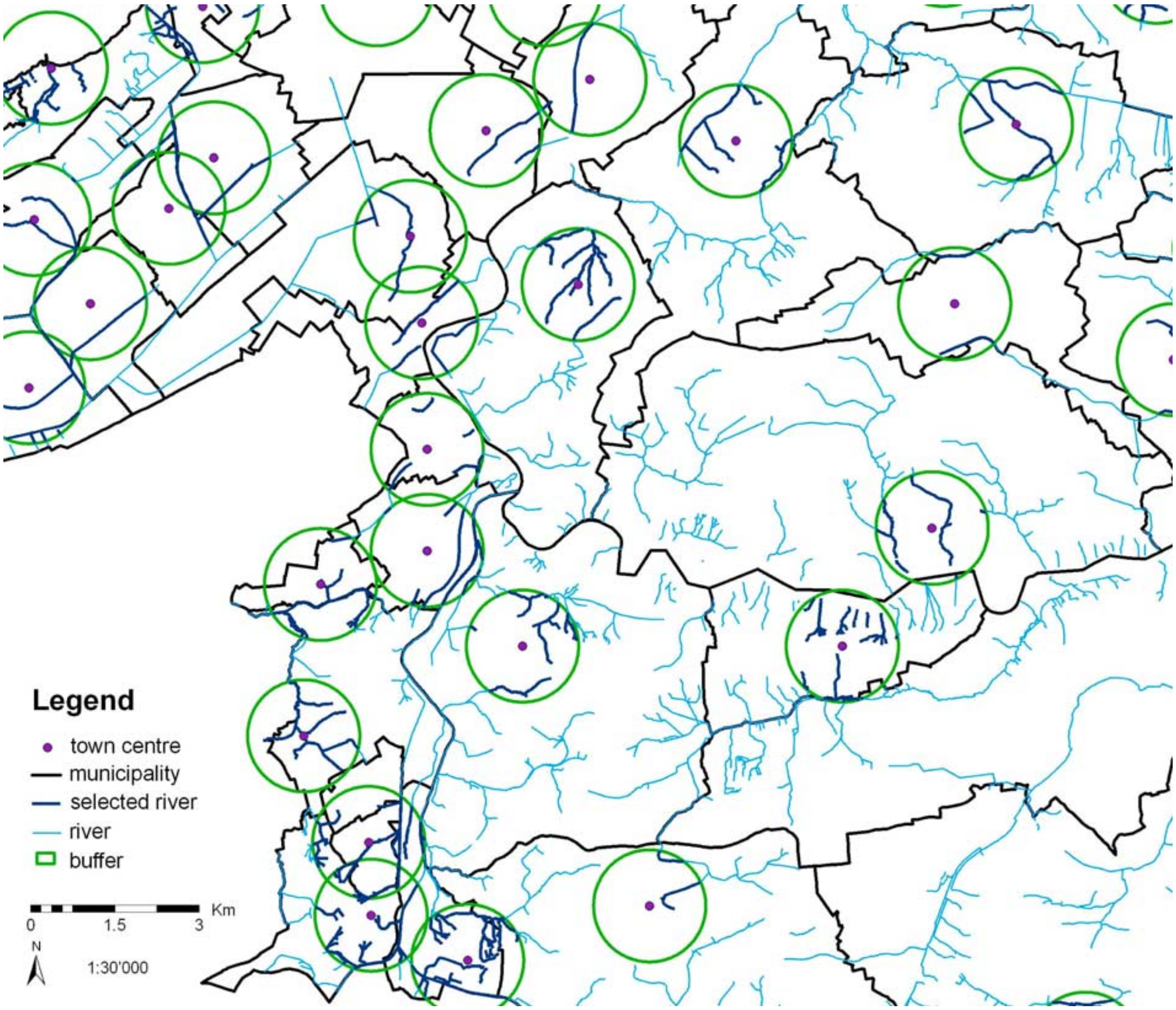

Figure 2. Creating variables for local density and ecomorphological status of rivers using a geographic information system.

$(n_i F_i(1 - F_i))^{1/2}$ as the weighting variable, where n is the number of valid votes cast in municipality i [*Maddala*, 1983]. Hence observations from municipalities with larger voter populations are given more weight. Weighting is called for when the individual errors are independent; because of averaging, the observations from large municipalities have smaller errors (are more informative) than the observations from small counties [*Kahn and Matsusaka*, 1997]. However, if the within-municipality errors are positively correlated, as they may be if there are omitted

Table 3. Descriptive Statistics of the Independent Variables Used in Regressions

Variable Name	Description	Mean (SD)[a]	Expected Sign
INCOME	mean net income of taxpayers in the municipality (1000 SFR)	52.5 (7.86))	?
POPDENS	number of inhabitants per hectare	2.54 (4.54)	+
LANGUAGE	dummy variable for local language (1 = German only; 0 = French)	0.89 (0.37)	?
DAMAGE	dummy variable for experience of flood(s) or landslide(s) 1987–1997 (1 = yes; 0 = no)	0.51 (0.50)	?
RIVDENS_r	density of rivers within radius r from the main residential center (km/km^2)	r = 1 km: 1.68 (0.87) r = 2 km: 1.42 (0.65) r = 5 km: 1.23 (0.52)	+
RIVNAT_r	"naturalness" of the river ecosystems within radius r from the main residential center (see Tables 1 and 2)	r = 1 km: 2.87 (0.82) r = 2 km: 3.09 (0.63) r = 5 km: 3.23 (0.51)	–

[a]SD indicates the standard deviation.

Table 4. Estimates of Regression Models to Explain Voter Support for River Restoration Including Variables for River Ecomorphology Within a Radius of 1, 2, and 5 km From the Residential Centers[a]

	r = 1 km			r = 2 km			r = 5 km		
	OLS	OLS Het.	WLS	OLS	OLS Het.	WLS	OLS	OLS Het.	WLS
Constant	−0.783 (−0.75)	−0.783 (−0.71)	−1.017 (−1.60)	−1.152 (−1.13)	−1.152 (−1.20)	−0.831 (−1.36)	−0.857 (−0.76)	−0.857 (−0.74)	−1.029 (−1.40)
logINCOME	0.346 (1.36)	0.346 (1.35)	0.237 (1.50)	0.377 (1.55)	0.377 (1.61)	0.154 (1.04)	0.272 (1.13)	0.272 (1.12)	0.150 (1.01)
logPOPDENS	0.149[b] (4.29)	0.149[b] (3.32)	0.103[b] (4.94)	0.149[b] (4.52)	0.149[b] (3.82)	0.114[b] (5.76)	0.144[b] (4.47)	0.144[b] (4.08)	0.117[b] (6.21)
LANGUAGE	−0.295[c] (−2.33)	−0.295 (−1.09)	0.096[d] (1.70)	−0.212[c] (−2.05)	−0.212 (−1.24)	0.063 (1.24)	−0.212[c] (−2.08)	−0.212 (−1.27)	0.060 (1.18)
DAMAGE	0.012 (0.20)	0.012 (0.23)	0.022 (0.54)	0.011 (0.18)	0.011 (0.21)	0.022 (0.55)	0.021 (0.37)	0.021 (0.40)	0.025 (0.63)
JURA	−0.215[d] (−1.80)	−0.215 (−0.90)	0.028 (0.46)	−0.157 (−1.51)	−0.157 (−0.99)	0.007 (0.12)	−0.153 (−1.40)	−0.153 (−0.95)	0.045 (0.71)
PREALPS	0.020 (0.21)	0.020 (0.29)	−0.008 (−0.14)	0.018 (0.19)	0.018 (0.26)	−0.003 (−0.05)	0.136 (1.31)	0.136 (1.44)	0.042 (0.65)
ALPS	0.257[c] (2.15)	0.257[c] (2.02)	−0.046 (−0.58)	0.231 (1.95)	0.231[d] (1.93)	−0.012 (−0.15)	0.251[d] (1.92)	0.251[c] (2.01)	0.034 (0.39)
RIVDENS$_r$ (RD)	−0.093 (−0.80)	−0.093 (−0.79)	0.041 (0.56)	0.013 (0.06)	0.013 (0.08)	0.213 (1.54)	0.419 (1.18)	0.419 (1.32)	0.515[c] (1.99)
RIVNAT$_r$ (RN)	−0.121[d] (−1.84)	−0.121[d] (−1.81)	−0.002 (−0.05)	−0.045 (−0.46)	−0.045 (−0.55)	0.068 (1.14)	0.007 (0.04)	0.007 (0.04)	0.108 (1.00)
RD × RN	0.029 (0.73)	0.029 (0.68)	−0.020 (−0.77)	−0.015 (−0.23)	−0.015 (−0.29)	−0.084[d] (−1.85)	−0.160 (−1.47)	−0.160[d] (−1.66)	−0.163[c] (−2.04)
n		354			365			366	
R^2	0.167	0.167	0.266	0.162	0.162	0.267	0.180	0.180	0.269
R^2adj.	0.142	0.142	0.245	0.138	0.138	0.246	0.156	0.156	0.248

[a]The dependent variable is logit-trasformed approval rate. Abbreviations: OLS, ordinary least squares; OLS Het., standard errors based on White's heteroscedasticity-consistent covariance matrix; WLS, weighted least squares. T values are in parentheses.
[b]Significant at $p < 0.01$.
[c]Significant at $p < 0.05$.
[d]Significant at $p < 0.1$.

municipality-level variables, then weighting can make things worse [*Kahn and Matsusaka*, 1997].

[27] In the analysis of cross-sectional data, spatial autocorrelation in the error term may result in underestimated standard errors and thus in incorrect inferences about the effects of the independent variables [*Anselin*, 1988]. Introducing dummy variables for districts comprising groups of municipalities is an effective means to detect and at least partly remove potential effects of autocorrelation on the standard errors. We therefore also computed models in which we included a set of dummy variables for the 26 "counties" (Bezirke) of the canton of Bern. The parameter estimates obtained for these global within-district effects were very similar to those of the models without the district dummies (the significance levels of the river variables were somewhat better) and are not reported here.

4. Results

4.1. Models of the Logit-Transformed Approval Rates

[28] Table 4 presents the models using the three alternative definitions of the local ecomorphological status (RIVNAT) and density (RIVDENS) of the rivers (with r = 1 km, r = 2 km and r = 5 km, respectively). Each model contains the OLS estimates with standard t values and t values based on White's heteroscedasticity-consistent standard errors as implemented in Limdep 7 [*Greene*, 1998]. The last column in each model reports the estimates of the weighted least squares regression (WLS). In presenting the results we follow the order of the variables in the regression table.

[29] Population density (variable POPDENS) in the municipalities was strongly positively associated with the approval rate in all models ($p < 0.01$). Mean income in the municipalities (INCOME) tended to be positively associated with public support of the initiative for financing river restoration, although the coefficients were not quite significant at conventional levels. The coefficient signs nevertheless show that among the municipalities of the canton of Bern, controlling for the other variables, higher mean incomes were associated with slightly higher approval rates. This result suggests that the income elasticity of willingness to pay for river restoration is greater than the income elasticity of the tax schedule [*Schläpfer et al.*, 2005].

[30] LANGUAGE (and related Germanic versus Romanic cultural background) was not consistently related to voter support. The significantly negative OLS and positive WLS estimates indicate that Germanic background had a negative effect on approval among the smaller municipalities only (which are given less weight in the WLS model). The occurrence of recent experience of flood damage (DAMAGE) did not affect voter support for river restoration. The Alpine municipalities (ALPS) had significantly higher approval rates than the (Swiss Plateau) reference in all OLS models (but not in the WLS models where the small municipalities receive less weight). This result can potentially be explained by an expectation in Alpine municipalities that river restoration projects would also serve flood control objectives.

[31] The quantity of local rivers within a certain distance from the population centers (RIVDENS$_r$) was not significantly related to the approval rates, except in the WLS

Table 5. Estimates of Marginal Effects (Linear Models)[a]

	Model 1		Model 2		Model 3	
	OLS Het.	WLS	OLS Het.	WLS	OLS Het.	WLS
Constant	42.06[b] (6.85)	44.70[b] (10.62)	39.19[b] (6.58)	44.33[b] (11.48)	38.78[b] (6.76)	48.98 [b] (12.91)
INCOME	0.29[b] (3.41)	00.15[b] (2.90)	0.29[b] (3.74)	0.17[b] (3.43)	00.35[b] (4.62)	0.22[b] (4.51)
POPDENS	0.32[b] (3.02)	00.20[b] (2.91)	0.35[b] (3.55)	0.25[b] (3.73)	—	—
LANGUAGE	−1.97 (−0.83)	2.68[c] (2.22)	0.00 (0.00)	2.42[c] (2.15)	—	—
DAMAGE	1.21 (1.01)	1.65[d] (1.77)	—	—	—	—
JURA	−3.27 (−1.40)	−0.93 (−0.65)	—	—	—	—
PREALPS	−1.41 (−0.91)	−1.02 (−0.73)	—	—	—	—
ALPS	1.21 (0.47)	−2.63 (−1.45)	—	—	—	—
$RIVDENS_{2km}$	−0.68 (−0.73)	−1.03 (−1.38)	—	—	—	—
$RIVNAT_{2km}$	−2.05[c] (−1.83)	−1.56[c] (−1.97)	−1.97[d] (−1.95)	−1.99[b] (−2.79)	−2.53[c] (−2.55)	−3.34[b] (−5.00)
n	265		365		365	
R^2	0.129	0.213	0.116	0.201	0.100	0.148
R^2adj.	0.107	0.193	0.106	0.192	0.095	0.143

[a]The dependent variable is the percentage of approving votes. Abbreviations: OLS, ordinary least squares; OLS Het., standard errors based on White's heteroscedasticity-consistent covariance matrix; WLS, weighted least squares. *T* values are in parentheses.
[b]Significant at $p < 0.01$.
[c]Significant at $p < 0.05$.
[d]Significant at $p < 0.1$.

model with r = 5 km. The naturalness of local rivers within a certain distance from the population centers ($RIVNAT_r$) was negatively associated with the approval rate in the standard OLS model with r = 1 km. The interaction of $RIVNAT_r$ and $RIVDENS_r$ was significantly negative in the WLS models with r = 2 km and r = 5 km and in the OLS-Het. model with r = 5 km. In all other models the (negative) coefficients on $RIVNAT_r$ were not significant at conventional levels. Hence higher "naturalness" of the local river was associated with lower approval rates, but with "local" defined by r = 2 km and r = 5 km this effect came through the interaction of naturalness with the local density of rivers. This result suggests that at greater distances from the centers the effect of ecomorphological status depended on river density.

[32] The R^2 values indicate that the proportion of the variance explained by the regressions is relatively small (about 16 to 18% in the OLS and 27% in the WLS models). Adding the "river variables" increased the proportion of explained variance by about 1.7% (Table 4; WLS model with r = 5 km). Potential reasons for the limited explanatory power of the models include the financing by ways of a progressive tax which may have prevented a sharp division of approval rates along the income variable. Furthermore, the relatively homogeneous spread of the river system over the entire canton may have prevented sharper regional differentiation of voter support [cf. *Deacon and Shapiro*, 1975]. (Including dummy variables for the 26 districts increased the proportion of explained variance by about 10%.)

4.2. Marginal Effects

[33] Table 5 presents a series of linear models explaining the (untransformed) percentage of approval of the river restoration proposition. The linear specification allows the coefficients to be interpreted as the marginal effects of changes in the independent variables on the percentage approval. Model 1 includes all independent variables of the previous models, except the interaction term. When the untransformed variables POPDENS and INCOME are entered in the model, both POPDENS and INCOME are highly significant, and the negative coefficient on river naturalness is also significant in both the OLS-Het. and the WLS model. Model 2 includes the significant variables of Model 1 (WLS), except DAMAGE which did not remain significant when the other variables were dropped. Model 2 thus represents a rough-and-ready formula to predict the percentage approval in the municipalities of the canton of Bern. (Depending on whether one prefers the estimates to be heavily determined by the larger towns or not, the WLS or the OLS estimates may be used. Hence, on the basis of the OLS estimates for instance, the percentage approval of the \$4 per capita and annum program for river restoration in the canton of Bern is given by:

$$\begin{aligned} \textit{Percentage Yes} = 44.3 &+ 0.25 * \text{POPDENS} + 0.17 * \text{INCOME} \\ &+ 2.4 * \text{LANGUAGE} - 2.0 * \text{RIVNAT}_{2km} \end{aligned}$$

Thus a ceteris paribus increase of mean income in a municipality by about CHF 1000 (or 2% at the mean of the municipalities' mean incomes) was associated with an increase of the approval rate by 0.17 percentage points. Hence a 20% (CHF 10,000) increase in mean annual income was associated with an increase of the approval rate by about 1.7 percentage points (e.g., from 54 to 55.7% approval). An increase of mean population density by 1 person per hectare increased approval rates by 0.25 percentage points. German language increased approval rate by 2.4 percentage points, and an increase of the mean river quality index by 1 point of the 5-point scale was associated with a reduction of the approval rate by 2 percentage points.

[34] Finally, Model 3 only includes INCOME and $RIVNAT_{2km}$, both highly significant. This model is of particular interest from a financing perspective (see also Conceptual framework, last paragraph). First, the income coefficient indicates if support increases with income – given the existing tax schedule. This simple information is of interest

because financing schemes for river restoration can account of how "fast" willingness to pay increases with income (while they cannot discriminate between, say, language groups or urban-rural differences in preferences). Second, the significant (negative) coefficient on $RIVNAT_{2km}$ suggests that naturalness is perceived as a local public good. The less natural local rivers were associated with greater public support for restoration. This suggests that (some) local participation in financing may be acceptable.

5. Conclusion

[35] The present empirical analysis based on georeferenced ecomorphological data, census data and aggregate voting returns suggests that population density was the main factor driving public support for river restoration in the municipalities of the Swiss canton of Bern. We further found evidence that the "naturalness" of local rivers derived from a set of ecomorphological attributes can be perceived by local populations and that this perception can affect local support for (regional) river restoration. Hence river restoration in the canton of Bern can tentatively be characterized as a public good with partly local benefits, and with a pronounced urban-rural difference in preferences. Given a progressive relevant tax schedule, the slightly positive association of approval rates with municipal mean income suggests a high income elasticity of willingness to pay.

[36] Other factors that were not of primary interest in the present study – but important as control variables – also appeared to determine the outcome of the vote. The geographic regions and language (with related cultural background) appeared to have some influence on the vote, although these effects depended on the size of the municipalities. While the dummy variable for recent experience of floods was not significant in the analysis, it cannot be excluded that a more sophisticated construction of the variable would have yielded different results.

[37] A main caveat regarding these results follows from the fact that our analyses using aggregate voting data explained only a limited proportion of the variation of aggregate voter support in the municipalities. While we argue that the analysis with respect to the factors income and local ecomorphological status of the rivers is of particular interest from a policy perspective, we suggest that the large proportion of unexplained variance invites further study. Important further local factors may have systematically influenced the perception of the ballot proposal in addition to those identified in the present study.

[38] From a public finance perspective, information about the distribution of public support of river restoration is clearly important for the design of efficient and widely acceptable policies. Moreover, if the goal is to promote efficient allocation and local identification through federalistic implementation, such information is important for assigning tasks and responsibilities to appropriate levels of government. The negative association of approval rates and river naturalness suggests that river restoration has a local benefit component. With regard to policy, this would suggest that efficient allocation may be pursued through a system of matching grants from the cantonal government and local jurisdictions actively participating in decision making and financing. When population density was dropped from regression models, mean income at the municipality level was strongly positively associated with aggregate approval rates – in spite of the progressive relevant tax schedule. With regard to financing schemes this result clearly suggests that financing through progressive taxes may be most appropriate. We suggest that our findings from the canton of Bern may be useful to inform river restoration in other Swiss cantons and perhaps other economically and culturally comparable regions.

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